Preliminary review of czechoslovak specifications, February 24, 1970

Pavel Marek
Load Factor Design for Steel Buildings

PRELIMINARY REVIEW OF CZECHOSLOVAK SPECIFICATIONS


ČSN 73 0035 Zatížení konstrukcí pozemních staveb Loading of Building Structures

ČSN 73 1401 Navrhování ocelových konstrukcí Design of Steel Structures

by

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For AISI - Task Group 163
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Limit States: These are defined as states at which the structure ceases to satisfy performance requirements. The structure shall be proportioned according to three limit states: strength, deformation, crack initiation.
Three Limit States are to be considered:

Limit State of Strength - proportioning of the structure (see Fig. 1) according to:

(a) the strength limit (elastic or plastic analysis may be used)

- "Adjusted" working load* ≤ minimum "adjusted" carrying capacity

(b) the stability limit (buckling, overturning, etc.)

(c) fatigue limit

- working load versus fatigue limits

(d) the fracture limit

- working load or "adjusted" working load* versus fracture limits

Limit State of Deformation - the designer must either prove:

- that the flexibility, deflection, vibrations, etc., are within permissible range with respect to service conditions, aesthetics;
- or he must keep to the limitations suggested in specifications.

Limit State of Crack Initiation (for concrete and composite structures)

*Working load probabilistically adjusted to account for maximum probable overrun in applied load.
LOADING ANALYSIS

Loading function as separate from resistance function.

\[ \text{working loads} \]

\[ \text{"adjusted" working loads} = \text{working load} \times \text{load factor } z \].

"Load Factors z"

<table>
<thead>
<tr>
<th>Probabilistic:</th>
<th>Mixed:</th>
<th>Deterministic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>steel member ( z = 1.1(0.9) )</td>
<td>wind ( z = 1.2 - 1.3 )</td>
<td>crane ( z = 1.2 - 1.3 )</td>
</tr>
<tr>
<td>concrete mem. ( z = 1.2(0.9) )</td>
<td>snow ( z = 1.4 )</td>
<td>vehicles ( z = 1.3 )</td>
</tr>
</tbody>
</table>

\[ \text{dead load (D)} \]

\[ \text{Loading:} \]

\[ \text{live load} \rightarrow \text{long-time} \quad (L_1) \]

\[ \text{short-time} \quad (L_2) \text{ see Fig. 2} \]

\[ \text{extraordinary} \quad (L_3) \]

Basic - \( (\Sigma D + \Sigma zL_1 + \text{[the most significant } zL_2]) \)

Broader - \( (\Sigma D + \Sigma zL_1 + 0.9 \times \text{[all possible } zL_2]) \)

Extraordinary - \( (\Sigma D + \Sigma zL_1 + 0.8 \times \text{[possible } zL_2] + \text{one } L_3) \)

Factor of simultaneous loading effect.
"Adjusted Stress R"

(a) variation of mechanical properties
(b) variation of sectional properties

(a) variation of $\sigma_y$:

Probability 0.001

$$\sigma_{y,\text{min}} = m \sigma_y - 3.09 d \sigma_y$$

Example: steel 37
2131 specimens

$m = 38.2$ ksi, $d = 2.03$ ksi

(b) variation of Area:

$$\bar{R} = \sigma_y \frac{A_a}{A}$$

$$R = m_R - 3.09 d_R$$

<table>
<thead>
<tr>
<th>Steel</th>
<th>&quot;Min $\sigma_y$&quot;*</th>
<th>&quot;Adjusted Stress R&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 373</td>
<td>36 - 30</td>
<td>30 - 28.5</td>
</tr>
<tr>
<td>11 423</td>
<td>37 - 34</td>
<td>31.5 - 30</td>
</tr>
<tr>
<td>11 523</td>
<td>52 - 49</td>
<td>41.5 - 40</td>
</tr>
</tbody>
</table>

*Depends on thickness (see ČSN 73 1401).
Examples:

**Axial and Shear Stress:**

\[
\sigma = \frac{N_a}{A_e} + \frac{M_x}{I_x} + \frac{M_y}{I_y} + \frac{B_x \omega}{I_\omega} \leq R
\]

\[
\tau = \frac{T_s}{I} + \frac{M_t}{I_t} + \frac{M_\omega S_\omega}{I_\omega} \leq R_s
\]

**Buckling stress:**

\[
C \frac{N_a}{A} \leq R
\]

---

**COMPARISON OF ALLOWABLE STRESS DESIGN AND LIMIT STATE DESIGN.**

**Example:**

\[D + L_2 = 100 \text{ kips} \quad \text{simple tension}\]

<table>
<thead>
<tr>
<th>Limit State Design (CSN) (Present) (R=30 ksi)</th>
<th>Allowable Stress Design (CSN) (Former) (\sigma_{all.} = \frac{\sigma_y}{FS} = \frac{36}{1.5} = 24 \text{ ksi.})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P^a = D \times 1.1 + L_2 \times 1.4)</td>
<td>(P = D + L_2)</td>
</tr>
</tbody>
</table>

required area:
(comparison, reflects influence of \(\frac{L_2}{D^2}\))

\[\text{Economy} \leftarrow \text{Higher Required Area}\]
### Factor of the Function Conditions "m"

This includes special conditions which are included neither in loading analysis nor in strength function.

E.G. - column is supposed to be pin-ended, but the end detail does not guaranty the centric application of the load. \((m = 0.9)\)

### Factors*

<table>
<thead>
<tr>
<th>Possibility of overloading</th>
<th>USA</th>
<th>CSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) single expression</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>(b) multiple expression</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Approximations and uncertain-ties in the method of strength analysis</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Quality of workmanship</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Presence of residual stresses and stress concentrations</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Under-run in physical properties of material</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Under-run of cross-sectional dimensions of members</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Location and intended use of structure</td>
<td>LF</td>
<td>x</td>
</tr>
<tr>
<td>Special conditions</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Simultaneous effect of loading</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

* see Commentary on Plastic Design in Steel - ASCE (p. 18).
recent developments in plastic design practice

by lynn s. beedle, f. asce, le-wu lu, a. m. asce and lee chong lim

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dead load
live load
long term
short term
extraordinary
combinations

loading

resistance

plastic limit
stability limit
elastic limit
fatigue
fracture
deflection
(vibration)

table 6.—load factors for plastic design in various countries

<table>
<thead>
<tr>
<th>country</th>
<th>assumed shape factor (1)</th>
<th>dead load (2)</th>
<th>dead load + live load (3)</th>
<th>dead load + live load + wind or earthquake forces (4)</th>
<th>number of load factors (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>u.s.a.</td>
<td>1.12</td>
<td>1.70</td>
<td>1.30</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>australia</td>
<td>1.15</td>
<td>1.75</td>
<td>1.40</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>belgium</td>
<td>1.12</td>
<td>1.68</td>
<td>1.49</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>canada</td>
<td>1.12</td>
<td>1.70</td>
<td>1.30</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>germany</td>
<td>1.71f</td>
<td>1.50f</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>india</td>
<td>1.15</td>
<td>1.85</td>
<td>1.40</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>south africa</td>
<td>1.17</td>
<td>1.75</td>
<td>1.40</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>sweden</td>
<td>1.15</td>
<td>1.75</td>
<td>1.40</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>united kingdom</td>
<td>1.15</td>
<td>1.75</td>
<td>1.40</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>czechoslovakia</td>
<td>1.20 (max.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hungary</td>
<td>1.05</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>japan</td>
<td>1.20</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>yugoslavia</td>
<td>1.20</td>
<td></td>
<td></td>
<td></td>
<td>several</td>
</tr>
</tbody>
</table>

under study

b \( F_s = 1.1 - 1.3; F_2 = 1.2 - 1.4; F_3 = 1.2 - 1.3; k = 0.87 \) for \( a_y = 34.3 \) ksi; and \( k = 0.80 \) for \( a_y = 51.4 \) ksi; \( D = \) dead load; \( L = \) live load; \( L_1 = \) regular (long-time) live load; \( L_2 = \) irregular (short-time) live load; \( E = \) earthquake force; \( f = \) shape factor; \( S = \) maximum snow load; and \( W = \) wind force.

c period of snowdrift: \( n = 0 \) for less than one month; \( n = 0.5 \) for one month; \( n = 1.0 \) for three months.
Fig. 1

(a) LOAD

- Dead load
- Live load, long-term
- Short-term wind
- Crane A lateral
- Crane B lateral
- Exceptional

(b) STRENGTH

- LOAD
- STRENGTH

Fig. 2